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(71)
ECO-AIRE COMPANY, INC.,
2051 N.E. 191 Drive, NORTH MIAMI BEACH , XX (US).

(72)
NELSON, JERRY (US).

(74)
MACRAE & CO.

(54) PROCEDE ET DISPOSITIF DE PURIFICATION DE REJETS D'APPAREIL ET DE DECONTAMINATION D'OBJETS

(54) METHOD AND APPARATUS FOR PURIFYING APPLIANCE EXHAUST AND REMOVING CONTAMINANTS FROM OBJECTS

(57)
A method and apparatus for purifying appliance exhaust is accomplished by an air purification system in which an air stream is drawn into the system (2) and flows through an ozone chamber (8). The ozone chamber (8) includes an ozone generating radiation source (12) that irradiates the air stream to generate ozone which oxidizes contaminants residing in the air stream. Subsequent to traversing the ozone chamber (8), the air stream enters a germicidal chamber (16) having a germicidal radiation source (14) that irradiates the air stream and destroys bacteria and breaks down ozone residing therein. The system (2) is typically disposed in an air flow path within an appliance, such as a vacuum cleaner, to treat the air and return purified air to a surrounding environment. Further, the system (2) may be configured to remove contaminants from objects, such as food, using a porous receptacle (15) to support the object in the ozone chamber (8). Additionally, the system may be configured to remove contaminants from a user's hand.

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(72) NELSON, JERRY, US
(71) ECO-AIRE COMPANY, INC., US

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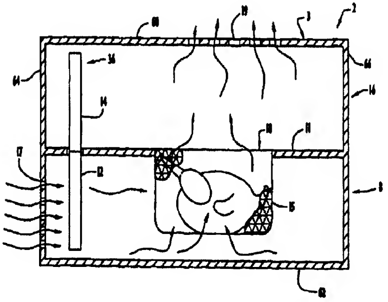
(54) **PROCEDE ET DISPOSITIF DE PURIFICATION DE REJETS D'APPAREIL ET DE DECONTAMINATION D'OBJETS**

(54) **METHOD AND APPARATUS FOR PURIFYING APPLIANCE EXHAUST AND REMOVING CONTAMINANTS FROM OBJECTS**



(57) La présente invention concerne un procédé et un appareil servant à purifier les rejets d'un appareil. Ledit procédé est et mis en oeuvre par un système de purification d'air dans lequel un courant d'air aspiré par le système (2) traverse une chambre d'ozonisation (8). Cette chambre d'ozonisation (8) comporte une source de rayonnement (12) produisant de l'ozone qui vient irradier le courant d'air de façon à générer de l'ozone qui oxyde les contaminants en suspension dans le courant

(57) A method and apparatus for purifying appliance exhaust is accomplished by an air purification system in which an air stream is drawn into the system (2) and flows through an ozone chamber (8). The ozone chamber (8) includes an ozone generating radiation source (12) that irradiates the air stream to generate ozone which oxidizes contaminants residing in the air stream. Subsequent to traversing the ozone chamber (8), the air stream enters a germicidal chamber (16) having a

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d'air. Après la traversée de la chambre d'ozonisation (8), le courant d'air pénètre dans une chambre microbicide (16) dotée d'une source de rayonnement (14) microbicide qui irradie le courant d'air et détruit les bactéries ainsi que l'ozone résiduel dans ce courant d'air. Le système (2) se monte généralement dans le passage d'un courant d'air à l'intérieur d'un appareil tel qu'un aspirateur de ménage, de façon à traiter l'air et à restituer de l'air purifié à l'atmosphère ambiante. l Le système (2) peut également être configuré pour décontaminer des objets, des aliments par exemple, placés dans un récipient poreux à l'intérieur de la chambre d'ozonisation (8). Par ailleurs, le système peut être configuré pour décontaminer les mains d'un utilisateur.

germicidal radiation source (14) that irradiates the air stream and destroys bacteria and breaks down ozone residing therein. The system (2) is typically disposed in an air flow path within an appliance, such as a vacuum cleaner, to treat the air and return purified air to a surrounding environment. Further, the system (2) may be configured to remove contaminants from objects, such as food, using a porous receptacle (15) to support the object in the ozone chamber (8). Additionally, the system may be configured to remove contaminants from a user's hand.

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(71) Applicant (*for all designated States except US*): ECO-AIRE COMPANY, INC. [US/US]; 2051 N.E. 191 Drive, North Miami Beach, FL 33179 (US).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): NELSON, Jerry [US/US]; 68 Zachariah Place, Warwick, RI 02889 (US).

(74) Agents: SHAPIRO, Stuart, B. et al.; Epstein, Edell & Retzer, Suite 400, 1901 Research Boulevard, Rockville, MD 20850-3164 (US).

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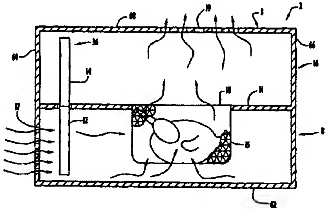

(57) Abstract

A method and apparatus for purifying appliance exhaust is accomplished by an air purification system in which an air stream is drawn into the system (2) and flows through an ozone chamber (8). The ozone chamber (8) includes an ozone generating radiation source (12) that irradiates the air stream to generate ozone which oxidizes contaminants residing in the air stream. Subsequent to traversing the ozone chamber (8), the air stream enters a germicidal chamber (16) having a germicidal radiation source (14) that irradiates the air stream and destroys bacteria and breaks down ozone residing therein. The system (2) is typically disposed in an air flow path within an appliance, such as a vacuum cleaner, to treat the air and return purified air to a surrounding environment. Further, the system (2) may be configured to remove contaminants from objects, such as food, using a porous receptacle (15) to support the object in the ozone chamber (8). Additionally, the system may be configured to remove contaminants from a user's hand.

METHOD AND APPARATUS FOR PURIFYING APPLIANCE EXHAUST AND REMOVING CONTAMINANTS FROM OBJECTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of copending U.S. Patent Application Serial No. 09/186,990, entitled "Method And Apparatus For Producing Purified Or Ozone Enriched Air To Remove Contaminants From Fluids", filed November 5, 1998, which is a continuation-in-part of U.S. Patent Application Serial No. 09/156,422, entitled "Method and Apparatus for Producing Purified or Ozone Enriched Air", filed September 18, 1998, which is a continuation-in-part of U.S. Patent Application Serial No. 08/932,101, entitled "Method and Apparatus for Removing Contaminants from a Contaminated Air Stream", filed on September 17, 1997. In addition, this application claims priority from U.S. Provisional Patent Application Serial No. 60/066,500, entitled "Method and Apparatus for Purifying Appliance Exhaust and Removing Contaminants from Objects", filed on November 24, 1997, and from U.S. Provisional Patent Application Serial No. 60/094,574, entitled "Method and Apparatus for Producing Purified or Ozone Enriched Air to Remove Contaminants from Objects", filed on July 29, 1998. The disclosures in the above-referenced patent applications are incorporated herein by reference in their entireties.

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention pertains to a method and apparatus for purifying an air stream within an appliance prior to that air stream returning to a surrounding environment. Further, the present invention pertains to a method and apparatus for removing contaminants from objects. In particular, the present invention pertains to a method and apparatus for exposing a contaminated air stream within an appliance, preferably a vacuum cleaner, to ozone and germicidal radiation to remove contaminants

from that air stream and return sterilized air to a surrounding environment. Moreover, the present invention pertains to a method and apparatus for producing ozone enriched air to remove contaminants from objects, such as food, hands, etc.

2. Discussion of Related Art

Currently, there are numerous devices known as deodorizing machines utilizing ozone and/or ultraviolet (UV) radiation to sanitize and deodorize air in a treated space (i.e., typically a room). Generally, these devices generate large amounts of ozone gas to attain the ozone concentration level necessary to facilitate deodorizing and sterilizing the air. Since ozone concentration levels required for sterilization are sufficiently high to be dangerous to people and/or animals, the use of these devices is typically limited to odors whose removal is difficult (e.g., smoke from fires, organic material spilled on clothing, etc.). Further, when the devices are used in the proximity of people and/or animals, health authorities require that ozone concentrations be reduced to safe levels. However, these reduced or "safe" levels tend to be too low to effectively deodorize and clean the air. Moreover, such devices typically use the germicidal qualities of the ultraviolet radiation to destroy bacteria in the air, but generally either expose the treated space to high levels of radiation, thereby posing health risks to people and/or animals, such as eye trauma and skin lesions, or use very low levels of radiation requiring long exposure times.

The prior art attempts to obviate the aforementioned problems by exposing air from the treated space to ozone or UV radiation internally of a device to thereby shield against the above-mentioned harmful effects. For example, Burt (U.S. Patent No. 3,486,308) discloses an air treatment device having a UV radiation source to sterilize air and a plurality of baffles disposed within the interior of the device housing. The baffles increase an air flow path within the device beyond the dimensions of the device housing to expose the air to radiation for greater periods of time. The UV source produces radiation at a particular intensity to avoid production of ozone.

Japanese Publication JP 1-224030 discloses an air cleaner including an ozone generating section, an ozone-air mixing section and a filter section. The filter section may include a pair of filters having an alkaline component and ozone-purifying material, respectively. Alternatively, the filter section may include a single filter having both an alkaline component and ozone-purifying material to clean air. The air cleaner further includes a winding air flow path for the air stream to traverse during cleaning.

The prior art devices disclosed in the Burt patent and Japanese Publication suffer from several disadvantages. In particular, the Burt device does not utilize ozone, thereby typically only removing bacterial contaminants (e.g., germs) within an air stream and enabling non-bacterial or other contaminants, such as odor causing contaminants, to be returned to a surrounding environment. Conversely, the air cleaner disclosed in the Japanese Publication employs only ozone to clean the air, thereby possibly destroying only a portion of bacterial contaminants within the air stream, while returning residual bacterial contaminants to a surrounding environment.

The prior art attempted to overcome the above mentioned disadvantages by employing ozone in combination with UV radiation to remove virtually all contaminants from an air stream. In particular, Chesney (U.S. Patent No. 2,150,263) discloses a system for internally cleaning, sterilizing and conditioning air within the system. A stream of air is washed and subsequently exposed to UV radiation which generates ozone such that the combination of UV radiation and ozone destroys virtually all bacteria in the air stream. Excess ozone is removed via pumps and utilized for various purposes.

Hirai (U.S. Patent No. 5,015,442) discloses an air sterilizing and deodorizing system wherein UV radiation generates ozone to oxidize and decompose odor-causing components in the air. The ozone is then removed by a catalyzer in conjunction with, and prior to, germicidal UV radiation where the UV radiation also removes germs and sterilizes the air.

Monagan (U.S. Patent No. 5,601,786) discloses an air purifier including a housing having an irradiation chamber, an air inlet for directing air into the irradiation chamber, a radiation source disposed within the irradiation chamber and an air outlet formed in the

housing for discharging air to the environment. The radiation source preferably emits ozone-producing radiation within one wavelength interval, and germicidal radiation within another wavelength interval, whereby the emitted radiation serves to destroy microorganisms and deodorize the air.

LeVay et al (U.S. Patent No. 5,614,151) discloses an electrodeless sterilizer using ultraviolet radiation and/or ozone. The sterilizer includes an energy source to excite a gas contained within a bulb and produce ultraviolet radiation, preferably strongest at 253.7 nanometers, that may be utilized to sanitize substances. Further, the radiation may be used to generate ozone that, either alone or in combination with the radiation, may sanitize substances. The bulb may be shaped to enable substances (e.g., liquid) to pass through the bulb for sterilization, or to enclose and shield objects (e.g., small articles) within the bulb from the energy source. Moreover, the bulb may be located at the end of a waveguide, or radiation may be transmitted from the bulb via an optic feed to sanitize inaccessible surfaces of substances. In addition, an ozone generator may be utilized to apply ozone to an external substance, whereby flexible hosing connected to the ozone generator includes a nozzle to control discharge of ozone onto a substance.

The Chesney, Hirai, Monagan and LeVay et al systems suffer from several disadvantages. Specifically, the Chesney and LeVay et al systems typically utilize a single wavelength of UV radiation (e.g., approximately 254 nanometers) which may not be optimal for both generating ozone and destroying bacteria. In fact, this wavelength is generally utilized for its germicidal effects and tends to destroy ozone, thereby degrading the effect of ozone within the air stream. Although the Monagan system utilizes a radiation source emitting ozone-producing and germicidal radiation, an air stream is exposed to each type of radiation simultaneously, thereby enabling the germicidal radiation to destroy produced ozone and degrade the effect of ozone within the air stream. Further, the Chesney system includes a relatively lengthy compartment for treating air, thereby increasing the size and cost of the system. The Hirai system typically utilizes independent radiation sources to generate ozone and germicidal radiation, thereby increasing system cost and complexity. Moreover, the Hirai system does not provide a

safety feature where the ozone generating source may be operable when the germicidal or ozone removing source becomes inoperable, thereby leading to emissions of dangerous ozone concentrations from the system. In addition, the Hirai system employs a relatively short, narrow area for ozone generation, while the Monagan system includes a radiation source having adjacent portions emitting ozone generating and germicidal radiation, and a substantially linear path disposed within an irradiation chamber for an air stream to traverse the radiation source. Thus, the effects of ozone within an air stream in the Hirai and Monagan systems are degraded since there is generally a minimal amount of time and/or space for the ozone to interact with the air prior to exposure to germicidal radiation.

Although the LeVay et al system may sanitize substances via ozone and ultraviolet radiation, the ozone is typically generated by a single wavelength of radiation (e.g., approximately 254 nanometers) that tends to destroy ozone as described above, thereby minimizing the effects of ozone on the substance. Further, the LeVay et al system sanitizes a liquid substance by introducing ozone into the liquid subsequent to exposure of that liquid to germicidal radiation, thereby enabling the liquid to contain ozone concentration levels sufficient to cause possible harm to people and/or animals that contact the treated liquid. The LeVay et al patent further discloses systems for applying ultraviolet radiation or ozone to surfaces of substances external of those systems. The radiation may be applied to the external substance via a light pipe or optic feed, while ozone may be applied via a nozzle disposed at an end of flexible hosing attached to an ozone generator. However, these devices may not fully expose the substance surfaces to the ultraviolet radiation or ozone, thereby incompletely sanitizing the substance. Moreover, the ultraviolet radiation or ozone is applied to the substance surfaces typically without preventive or containment measures, thereby enabling radiation and ozone to be released to the surrounding environment and cause possible harm to people and/or animals in the vicinity of the substance as described above.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to expose air streams within appliances to ozone and germicidal radiation to remove contaminants from those air streams and return purified air to a surrounding environment.

It is another object of the present invention to maintain ozone concentration levels at low or "safe" levels in a contaminant removal system by utilizing a single radiation source within the system to emit ozone generating and germicidal radiation of different wavelengths from different sections of the source to generate ozone within and to perform germicidal functions on an air stream residing in the system. The entire single radiation source can become disabled only as a unit, thereby preventing generation of ozone when the germicidal radiation or ozone-removing section is inoperable.

Yet another object of the present invention is to utilize ozone, either alone or in combination with germicidal radiation, to remove contaminants from objects (e.g., food items, hands, etc.).

The aforesaid objects are achieved individually and in combination, and it is not intended that the present invention be construed as requiring two or more of the objects to be combined unless expressly required by the claims attached hereto.

According to the present invention, a method and apparatus for purifying appliance exhaust is accomplished by an air purification system in which air is drawn in as a stream into the system housing and flows through an ozone generating chamber. An ozone generating ultraviolet (UV) radiation source disposed within the ozone chamber emits ultraviolet radiation having a wavelength of approximately 185 nanometers to irradiate the air and generate ozone which oxidizes contaminants (e.g., bacteria, virus, odor-causing element, etc.) residing in the air stream. The ozone chamber is typically configured to include winding or other types of air flow paths, or to induce a vortical air flow, to reduce air through-flow velocity and maintain the air stream within the ozone chamber for a residence time sufficient for the ozone to interact with the air. Subsequent to traversing the ozone chamber, the air stream enters a germicidal chamber disposed adjacent the ozone chamber. The germicidal chamber may also be configured to have winding or other types of air flow paths, and includes a germicidal UV radiation source.

The germicidal UV radiation source irradiates the air stream and destroys bacteria and breaks down ozone residing therein. The germicidal UV radiation source generates radiation having a wavelength of approximately 254 nanometers to destroy bacteria, viruses, mold spores and ozone remaining after the interaction of air and ozone in the ozone chamber. The radiation source typically includes a single combination UV radiation emitting bulb with different sections of the bulb emitting radiation of different respective wavelengths (e.g., 185 and 254 nanometers). The different sections of the bulb are disposed in the corresponding ozone and germicidal chambers. Alternatively, the radiation source may be implemented by separate independent bulbs emitting radiation having wavelengths of approximately 185 or 254 nanometers depending upon the chamber in which the bulb is disposed.

The resulting sterilized air from the germicidal chamber may pass through a catalytic converter disposed adjacent the germicidal chamber to remove any remaining ozone by either converting the ozone back to oxygen, or filtering the ozone from the air stream. An internal fan disposed adjacent the ozone chamber draws air into the system and through the chambers. The system is typically disposed in an air flow path within an appliance, such as a vacuum cleaner, to treat the air and return purified air to a surrounding environment.

Further, the system may be configured to remove contaminants from objects, such as food. Specifically, the system for removing contaminants from objects is similar to the air purification system described above, and includes a combination radiation source to provide ozone generating and germicidal radiation within the respective ozone and germicidal chambers. The ozone chamber includes a porous receptacle for supporting an object within the ozone chamber and enabling produced ozone within that chamber to interact with and remove contaminants from the object. The ozonated air stream from the ozone chamber flows through the porous receptacle and into the germicidal chamber, wherein the air stream is exposed to germicidal radiation to remove residual contaminants and ozone therefrom. The resulting sterilized air is returned to the surrounding environment.

In addition, the system may be configured to remove contaminants from a user's hands. In particular, the system for removing contaminants from a user's hands is similar to the air purification system described above, except that the system includes a single treatment chamber having independent ozone generating and germicidal radiation sources. The hands are inserted into the treatment chamber, whereby each radiation source is enabled for a predetermined time interval. The ozone generating radiation source initially generates ozone within the treatment chamber to remove contaminants from the user's hands, while the germicidal radiation source is subsequently enabled to expose those hands to germicidal radiation to remove residual contaminants and ozone therefrom.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of specific embodiments thereof, particularly when taken in conjunction with the accompanying drawings wherein like reference numerals in the various figures are utilized to designate like components.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view in elevation and partial section of a portion of an exemplary system of the type employed by the present invention to produce purified or ozone enriched air.

Fig. 2 is a view in elevation and partial section of a system utilizing ozone enriched air to remove contaminants from various objects according to the present invention.

Fig. 3 is an exploded view in perspective and partial section of a system utilizing ozone and germicidal radiation to remove contaminants from a user's hands according to the present invention.

Fig. 4 is a side view in elevation and partial section of the system of Fig. 3.

Fig. 5 is a side view in elevation and partial section of an upright vacuum cleaner having a system to purify an air stream within the vacuum cleaner prior to that air stream returning to a surrounding environment according to the present invention.

Fig. 6 is a side view in elevation of an alternative type of vacuum cleaner having a system to purify an air stream within the vacuum cleaner prior to that air stream returning to a surrounding environment according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An exemplary system of the type disclosed in the aforementioned patent applications for removing contaminants from a contaminated air stream to produce purified and/or ozone enriched air is illustrated in Fig. 1. Specifically, the system includes a housing 5, ozone and germicidal chambers 8, 16, an ultraviolet (UV) radiation source 36, typically implemented by a combination ultraviolet radiation emitting bulb and disposed toward the approximate center of the ozone and germicidal chambers, a ballast (not shown), preferably conventional, for supplying current to radiation source 36, and an internal fan (not shown) for drawing air through the system. The radiation source may be implemented by a single bulb having an ozone section 12 and germicidal section 14 emitting radiation at different wavelengths (e.g., 185 and 254 nanometers) from the ozone and germicidal sections as disclosed in the above-referenced patent applications. Alternatively, the radiation source may be implemented by independent bulbs disposed in the respective ozone and germicidal chambers, whereby the bulb disposed in the ozone chamber emits ozone generating radiation (e.g., having a wavelength of approximately 185 nanometers), while the bulb disposed in the germicidal chamber emits germicidal radiation (e.g., having a wavelength of approximately 254 nanometers).

Air from a surrounding environment is drawn into the system through an air intake (not shown) via the internal fan (not shown) and is directed by the internal fan and the housing internal structure to flow into ozone chamber 8, typically disposed above and adjacent the internal fan and air intake. Ozone chamber 8 includes ozone section 12 of radiation source 36 and a tortuous or serpentine path 10 that serves to decrease air

through-flow velocity (i.e., the path increases residence time of an air stream within the ozone chamber, thereby decreasing velocity of the air stream through the chamber) and enhance ozone distribution within the air stream in substantially the same manner described in the above-referenced patent applications. Path 10 receives an air stream entering ozone chamber 8 from the approximate bottom center of the ozone chamber proximate ozone section 12, and transversely directs the air stream away from ozone section 12 toward the system housing through successive passageways that alternate the direction of air stream flow within the ozone chamber. It is to be understood that the terms "top", "bottom", "upper", "lower", "front", "rear", "back", "side", "horizontal", "vertical" and "length" are used herein merely to facilitate descriptions of points of reference and do not limit the present invention to any specific configuration or orientation. Ozone section 12 emits ozone generating radiation to produce ozone within the air stream, while path 10 reduces air through-flow velocity and enables the produced ozone to mix and interact with the air stream to oxidize contaminants. Once the air stream traverses path 10, the air stream exits the ozone chamber and enters germicidal chamber 16. Germicidal chamber 16 includes germicidal section 14 of radiation source 36 that emits germicidal UV radiation to destroy contaminants and ozone within the air stream. The sterilized air from the germicidal chamber is exhausted from the system to the surrounding environment. The system ozone and germicidal chambers may each include various configurations as disclosed in the aforementioned patent applications. For example, the ozone chamber may include any of the configurations disclosed in the above-mentioned patent applications to reduce air through-flow velocity and enhance distribution of ozone within the air stream.

Ozone enriched air may be produced and utilized by a system to remove contaminants from various objects, such as food (e.g., meat, chicken, produce, etc.), kitchen utensils (e.g., cutting boards, knives, forks, etc.) or other instruments. These items may contain various microbes, such as E-coli or salmonella, that may cause illness. An exemplary system for removing contaminants from food or other objects is illustrated in Fig. 2. Specifically, system 2 includes a housing 3, ozone and germicidal chambers 8,

16 as described above, radiation source 36, preferably having ozone section 12 and germicidal section 14 as described above, a chamber divider 11 and a receptacle 15. Housing 3 typically includes top and bottom walls 60, 62, front and rear walls (not shown), and side walls 64, 66 that are each substantially rectangular and collectively define the system interior. Divider 11 is substantially similar to the housing top and bottom walls, and is disposed toward the approximate centers of the housing front, rear and side walls. The divider extends across the system interior to separate and isolate the ozone and germicidal chambers. Radiation source 36 is disposed toward system side wall 64 and through divider 11 to position ozone section 12 and germicidal section 14 in the ozone and germicidal chambers, respectively. Divider 11 includes an opening 18 defined toward the approximate center of the divider to enable an air stream to flow from ozone chamber 8 into germicidal chamber 16. However, opening 18 may be defined at any location along the divider. Receptacle 15 is typically constructed of mesh netting or any other type of porous material to retain food or other objects within the receptacle, whereby the porous material is attached to divider 11 toward the periphery of opening 18 to suspend the receptacle within the ozone chamber. The receptacle is disposed proximate opening 18 such that an air stream from ozone chamber 8 is directed to flow through the receptacle in order to enter germicidal chamber 16.

An air stream from a surrounding environment enters system 2 via slots 17, typically defined within the bottom portion of system side wall 64 adjacent radiation source 36. Slots 17 may be of any quantity (e.g., at least one), shape or size and may be defined and arranged in side wall 64 in any fashion. The air stream may be drawn into and through the system via an internal fan (not shown) as described above, while ozone section 12 emits ozone generating radiation within ozone chamber 8 to generate ozone within the air stream. Since the air stream is directed to traverse receptacle 15 and opening 18, the air stream velocity through the ozone chamber is reduced, thereby enabling the generated ozone to mix and interact with the air stream to remove contaminants from the air stream. When the ozone enriched air flows through receptacle 15 in order to traverse opening 18, the object contained within the receptacle becomes

soaked with the ozone enriched air, thereby enabling the ozone to remove contaminants from the object. After traversing receptacle 15 and opening 18, the air stream enters germicidal chamber 16 wherein germicidal section 14 of radiation source 36 exposes the air stream to germicidal radiation to remove contaminants and ozone from the air stream. The purified air stream is subsequently returned to the surrounding environment via slots 19, typically defined within top wall 60 or upper portions of side walls 64, 66. Slots 19 may be of any quantity (e.g., at least one), shape or size, and may be defined and arranged in any fashion in the top or side walls, or any combination of those walls.

A further application for purified and/or ozone enriched air is to remove contaminants from hands, especially hands of employees of restaurants or other food service establishments. A system for removing contaminants from hands utilizing ozone and germicidal radiation is illustrated in Figs. 3 - 4. Specifically, system 20 has a configuration similar to the systems described above and includes a treatment chamber 23 having an ozone generating radiation source 22 and a germicidal radiation source 62. The system includes top and bottom walls 70, 72, front and rear walls 74, 76 and side walls 78, 80 that form a box-like housing 3. The walls are each substantially rectangular and collectively define a system interior. Openings 24 are defined in housing front wall 74 for placement and removal of hands 26 within the system. A person typically inserts his/her hands through openings 24 into the system treatment chamber for a short time interval to enable ozone and germicidal radiation to remove any contaminants from the hands in substantially the same manner described above. Openings 24 generally include flaps 25 that form a seal with hands 26 to enable entry and removal of hands 26 within treatment chamber 23, while preventing ozone from escaping the system.

Radiation sources 22, 62 are generally disposed in the upper portion of the system substantially in parallel to each other, and extend between system side walls 78, 80. A fan 27 is disposed near an air intake (not shown) and ozone radiation source 22 to direct incoming air toward that source to generate ozone. A soaking chamber 21 is disposed adjacent ozone radiation source 22 to enable generated ozone to mix and interact with the air. In particular, a divider 82 extends from an intermediate portion of system top wall 70

into the system interior to isolate the ozone generating radiation source and soaking chamber from the germicidal radiation source. Dividers 84, 86 extend between housing rear wall 76 and divider 82 to define and isolate the confines of the soaking chamber. Divider 84 is disposed adjacent radiation source 22, while divider 86 extends from the terminal portion of divider 82 toward the intermediate portion of rear wall 76. The soaking chamber typically includes a winding or other type of path 10 to enhance distribution of ozone within the air stream as described above. The path is formed by a series of interleaved dividers 88, 90 directing the air stream in a serpentine fashion. Specifically, dividers 88 each extend from divider 82 toward rear wall 76. The length of each divider 88 is less than the distance between rear wall 76 and divider 82 to form respective gaps between dividers 88 and the rear wall. Similarly, divider 90 extends from rear wall 76 toward divider 82. The length of divider 90 is less than the distance between rear wall 76 and divider 82 to form a gap between divider 90 and divider 82. Divider 90 is disposed between dividers 88 to form successive passageways collectively defining serpentine path 10, whereby the gaps enable air to traverse succeeding passageways. An opening 92 is defined in divider 84 toward divider 82, while an opening 96 is defined in divider 86 toward rear wall 76. Openings 92, 96 enable the air stream to traverse path 10 and treat hands 26 residing within the treatment chamber. The ozone flows with the air stream toward hands 26 inserted within the system treatment chamber near the treatment chamber floor to oxidize and remove contaminants from the hands in substantially the same manner described above. Subsequently, hands 26 are exposed to germicidal radiation from germicidal radiation source 62 for a short time interval to remove bacteria and ozone from the hands in substantially the same manner described above.

The system may include a microprocessor or other control circuitry to initiate power to fan 27 and ozone radiation source 22 for a predetermined time interval to enable generation of ozone and oxidation of contaminants as described above. Upon expiration of the predetermined interval, power is disabled to fan 27 and ozone radiation source 22 to prevent ozone generation. The ozone concentration may thus be controlled based on the length of this interval. Germicidal radiation source 62 is initiated subsequent to

expiration of the ozone generation interval to expose hands 26 to germicidal radiation to remove bacteria and ozone from the hands as described above. The germicidal radiation source is similarly activated for a predetermined time interval, and then disabled to permit removal of hands 26 from the system. An alarm or other indicator may be disposed on the system to indicate completion of the treatment. The ozone generation and germicidal intervals and other parameters may be programmed into the system via a control panel (not shown).

The systems described above may be adapted to be of any size or shape and include D.C. ballasts for powering the radiation sources in order to be transportable and/or utilized in various vehicles (e.g., cars, boats, trucks, buses, trains etc.) or other areas. The D.C. ballasts may receive power from conventional batteries or cigarette lighters to enable the systems to be utilized at various remote locations. For example, the food sterilization system may be transportable for removing contaminants from food at picnics, barbecues or any other indoor or outdoor gatherings, while the hand system may similarly be transportable to facilitate cleaning of hands at virtually any location.

The generation of ozone enriched and/or purified air may be utilized for various other applications. For example, the systems described above and disclosed in the aforementioned patent applications may be employed within various appliances, such as vacuum cleaners, to purify air streams within these appliances prior to the air streams returning to a surrounding environment as illustrated in Fig. 5. Specifically, a conventional upright vacuum cleaner 30 generally includes a base or head 38, typically housing a motor (not shown) and a substantially cylindrical brush assembly 39, a handle 32 and a bag 34 attached to handle 32 for collecting particles removed from a carpet or floor by the vacuum cleaner. Bag 34 is typically a hard bag, commonly utilized with vacuum cleaners, that includes top, bottom, front, rear and side walls to collectively define a bag interior, and a collection chamber (not shown) to collect particles within the bag. The vacuum cleaner motor draws air into head 38 via an inlet 37 disposed toward the front bottom portion of the head. Brush assembly 39 is disposed within inlet 37 and includes brushes disposed on its exterior surface. The brush assembly rotates about its

longitudinal axis, whereby the brushes direct particles from a carpet or floor toward an air stream flowing into inlet 37. The air stream carries the particles and flows from inlet 37 through head 38 into bag 34 (e.g., as indicated by the arrows in Fig. 5), whereby the particles carried by the air stream are deposited within the bag collection chamber (not shown). The collection chamber typically includes an air porous bag or plastic container (not shown) that acts similar to a filter to permit an air stream to flow through the collection chamber, while retaining particles carried by the air stream within the collection chamber. Subsequent to flowing through the collection chamber, the air stream traverses slots 35, typically defined in a side wall of bag 34 toward the bag rear wall, to return to a surrounding environment.

An air purification system 50 may be disposed within bag 34 between the collection chamber and slots 35 to purify an air stream prior to the air stream returning to a surrounding environment. System 50 is typically substantially similar to the system described above for Fig. 1, but may be implemented by any of the systems described above or disclosed in the aforementioned patent applications that are capable of purifying air. System 50 receives the air stream via an intake 31 and exposes the air stream to ozone and germicidal radiation to remove contaminants from the air stream in substantially the same manner described above. Purified air exits system 50 via an exhaust vent 33, whereby the purified air traverses slots 35 of bag 34 to return to the surrounding environment. Thus, upright vacuum cleaner 30 draws an air stream from the surrounding environment into the vacuum cleaner to collect particles, while returning purified air back to the surrounding environment.

Alternatively, system 50 may be employed by vacuum cleaners of the type having a separate cleaning unit attached to a base and handle as illustrated in Fig. 6. Specifically, a conventional vacuum cleaner 40 generally includes a cleaning unit 41, typically housing a motor (not shown), and collection unit 47, typically including a base 42 and a handle 44. The vacuum cleaner motor draws an air stream into base 42 via an inlet 46 disposed toward the front bottom portion of the base. Base 42 typically includes a substantially cylindrical brush assembly 48 having brushes disposed on its exterior

surface. The brush assembly is disposed within inlet 46 and rotates about its longitudinal axis, whereby the brushes direct particles from a carpet or floor toward an air stream flowing into inlet 46. Handle 44 is attached to base 42 to enable manipulation of the base over the carpet or floor, and is further connected to cleaning unit 41 via a hose 45. The air stream carries the particles and flows from inlet 46 into base 42 and through handle 44 and hose 45 into a collection chamber (not shown) disposed within cleaning unit 41 (e.g., as indicated by the arrows in Fig. 6), whereby the particles carried by the air stream are deposited within the collection chamber. The collection chamber typically includes an air porous bag or plastic container (not shown) that acts similar to a filter to permit an air stream to flow through the collection chamber, while retaining particles carried by the air stream within the collection chamber. Subsequent to flowing through the collection chamber, the air stream traverses slots 43, defined toward a rear portion of the cleaning unit housing, to return to a surrounding environment.

An air purification system 50, substantially similar to the system described above for Fig. 5, may be disposed within cleaning unit 41 between the collection chamber and slots 43 of cleaning unit 41 to purify an air stream prior to the air stream returning to a surrounding environment. System 50 receives the air stream via an intake 31 and exposes the air stream to ozone and germicidal radiation to remove contaminants from the air stream in substantially the same manner described above. Purified air exits system 50 via an exhaust vent 33, whereby the purified air traverses slots 43 to return to the surrounding environment as described above. System 50 may be disposed in any type of vacuum cleaner, including vacuum cleaners having soft bags, at any location along an air flow path to purify an air stream within the vacuum cleaner. Further, system 50 may be disposed in any appliance at any location along an air flow path to enable the appliance to return purified air to a surrounding environment in substantially the same manner described above.

It will be appreciated that the embodiments described above and illustrated in the drawings represent only a few of the many ways of implementing a method and apparatus for purifying appliance exhaust and removing contaminants from objects.

The ballasts for the radiation sources of the systems described above may be implemented by any conventional DC (e.g., for portable systems) or AC ballast or other circuitry to supply current to the radiation sources. The systems described above may be of any shape or size, may be constructed of any suitable materials, and may include any quantity of radiation sources (e.g., at least one) of any shapes or size disposed in any manner within the systems. The internal fan of the systems described above may be implemented by any quantity of any conventional or other types of fans or devices for drawing air through a system, such as a fan, blower or device to create a differential pressure in a system to cause air flow through that system. The fan or other devices may be disposed internal or external of a system in any manner capable of directing air through that system. Further, the fan or devices may include variable flow rates to cause air to flow through a system at various rates. For example, larger areas may require greater flow rates to enable air within these larger areas to be rapidly and efficiently treated by a system. The components of the systems described above may be arranged in any fashion.

The system for removing contaminants from objects may be of any shape or size, and may accommodate various objects. The ozone chamber may include a portion of the germicidal section of the radiation source to expose the object to germicidal radiation to enhance removal of contaminants. The slots for receiving and exhausting air from the system may be of any quantity (e.g., at least one) shape or size, and may be defined at any suitable locations in any of the system housing walls. The combination radiation source may include any proportion of ozone section to germicidal radiation section, may be configured to emit radiation of any desired wavelengths, and may alternatively be implemented by independent radiation sources disposed within the ozone and germicidal chambers and emitting radiation of any desired wavelengths. Further, the combination radiation source typically only operates when each section is operable to prevent ozone generation without germicidal radiation to destroy the ozone. The chamber divider and ozone and germicidal chambers may be arranged in any fashion within the system. The receptacle may be formed of any porous material and may be disposed at any location

within the ozone chamber. Moreover, the receptacle may enable the object to be partially disposed in the germicidal chamber for exposure to germicidal radiation. The object may alternatively be retained in the ozone and/or germicidal chambers via any suitable receptacles, containers, securing mechanisms, or in any conventional or other manners (e.g., resting on the ozone chamber floor). The ozone chamber may further include a tortuous path as described above to enable the ozone to mix with the air. The ozone and/or germicidal chambers may include any quantity of receptacles arranged in any fashion to expose various quantities of objects to ozone and/or germicidal radiation. The ozone and germicidal chambers may include any suitable configurations to treat the air stream, such as the configurations described above or disclosed in the above-mentioned patent applications. The system may include any quantity (e.g., at least one) of ozone and germicidal chambers each having a suitable configuration to treat the object and/or air. In addition, the system may include a single chamber exposing the object and air to ozone and germicidal radiation.

The system for removing contaminants from hands may be of any shape or size, may be programmed to treat the hands for any desired time intervals, and may include any quantity (e.g., at least one) of combination or independent radiation sources of any shape or size disposed and/or arranged within the system in any fashion. The combination radiation sources may include any proportion of ozone section to germicidal radiation section, while the combination and independent radiation sources may be configured to emit radiation of any desired wavelengths. The combination radiation source enables simultaneous application of ozone and germicidal radiation to the hands for a predetermined time interval, and typically only operates when each section is operable to prevent ozone generation without germicidal radiation to destroy the ozone. The system may further treat objects inserted into the treatment chamber in substantially the same manner described above. The system may include any quantity of openings (e.g., at least one) to accommodate any quantity of hands during a treatment cycle. The openings defined in the system housing may be of any shape or size, and may be defined at any suitable locations in any of the system housing walls. The openings may include

any quantity (e.g., at least one) of flaps, or other devices to maintain ozone and radiation within the system. The soaking, ozone and germicidal chambers may include any suitable configurations to treat the air stream, such as the configurations described above or disclosed in the above-mentioned patent applications. Further, the soaking chamber path may include any path or other configuration capable of reducing air through-flow velocity and enabling the ozone to mix and interact with the air. A path of this type may be similarly disposed in the ozone and germicidal chambers. The system may include any conventional or other control pad and processor or control circuitry to control system operation as described above.

The air purification system may be of any size or shape, and may be disposed at any location within any appliance or other device exhausting an air stream (e.g., vacuum cleaner, blender, mixer, computer, etc.). The air purification system may be implemented by any of the systems described above or disclosed in the above-mentioned patent applications capable of purifying air. The air purification system may include a catalytic converter or other filter disposed adjacent the germicidal chamber to remove residual ozone from the air stream. The system may include any quantity (e.g., at least one) of ozone and germicidal chambers, whereby each chamber may have any suitable configuration, shape or size to treat air. Further, the system may include a single chamber exposing the air stream to ozone and germicidal radiation. Moreover, the system may utilize any quantity (e.g., at least one) of independent radiation sources of any shape or size within each chamber, or any quantity (e.g., at least one) of combination radiation sources of any shape or size having a plurality of sections with each section disposed in and emitting radiation at an appropriate wavelength for a corresponding chamber. The combination radiation source may include any proportion of ozone section to germicidal radiation section, while the combination and independent radiation sources may be disposed within the system in any fashion and be configured to emit radiation of any desired wavelengths. The combination radiation source typically only operates when each section is operable to prevent ozone generation without germicidal radiation to destroy the ozone. The air flow path within the system ozone chamber may include any

path or other configuration capable of reducing air through-flow velocity and enabling the ozone to mix and interact with the air. A path of this type may similarly be disposed within the germicidal chamber. The system intake and exhaust may be disposed on the system in any fashion to accommodate a device air flow, while the air flow may enable air to traverse the system without use or inclusion of a system fan.

It is to be understood that the present invention is not limited to the specific embodiments discussed herein, but may be implemented in any manner that utilizes ozone generation via a configuration that reduces air through-flow velocity to enable the ozone to interact with the air (e.g., any path configuration or other mechanism to reduce air through-flow velocity), and germicidal radiation to remove contaminants. Further, the present invention is not limited to the specific applications disclosed herein, but rather, may be utilized for any application employing or producing purified or ozone enriched air.

From the foregoing description it will be appreciated that the invention makes available a novel method and apparatus for purifying appliance exhaust and removing contaminants from objects wherein air is exposed to UV radiation at a first wavelength to generate ozone while traversing an ozone chamber configured to reduce air through-flow velocity and to enhance ozone distribution in the air. The ozone oxidizes contaminants in an air stream and/or object, whereby the air stream and/or object is subsequently exposed to UV radiation at a second wavelength to remove bacteria and ozone therefrom.

Having described preferred embodiments of a new and improved method and apparatus for purifying appliance exhaust and removing contaminants from objects, it is believed that other modifications, variations and changes will be suggested to those skilled in the art in view of the teachings set forth herein. It is therefore to be understood that all such variations, modifications and changes are believed to fall within the scope of the present invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A system for producing ozone enriched air to remove contaminants from objects comprising:

an air intake to receive an air stream from a surrounding environment;

air flow control means for directing the air stream to flow through said system;

an ozone chamber having an ozone generating radiation source for irradiating the air stream to produce ozone to remove contaminants from within the air stream resulting in an ozonated air stream, and a receptacle for receiving and supporting an object within said ozone chamber, wherein said receptacle is configured to enable the ozonated air stream to infiltrate said receptacle and remove contaminants from said object;

a germicidal chamber for receiving said ozonated air stream from said receptacle within said ozone chamber and including a germicidal radiation source for irradiating the ozonated air stream to remove residual contaminants and at least a portion of ozone therefrom to produce sterilized air; and

an exhaust for returning the sterilized air to the surrounding environment.

2. The system of claim 1 wherein said receptacle includes a porous material.

3. The system of claim 2 wherein said porous material includes mesh netting.

4. The system of claim 1 wherein said ozone generating radiation source and said germicidal radiation source correspond to ozone and germicidal sections of a radiation bulb emitting radiation having different wavelengths at different sections of said bulb.

5. A system for producing ozone enriched air to remove contaminants from objects comprising:

an air intake to receive an air stream from a surrounding environment;

air flow control means to direct the air stream to flow through the system; and

a treatment chamber including:

access means for facilitating placement and removal of an object within said treatment chamber;

an ozone generating radiation source for irradiating the air stream to produce ozone;

a soaking chamber disposed proximate said ozone generating radiation source and including ozone distribution means for increasing residence time of said air stream in said soaking chamber to enable the produced ozone to thoroughly mix and interact with and ozonate the air stream, and guide means to direct said ozonated air stream toward said object to interact with and remove contaminants from said object; and

a germicidal radiation source for irradiating the object to remove residual contaminants and ozone therefrom.

6. The system of claim 5 wherein said ozone generating radiation source and said germicidal radiation source are each independent radiation sources, and said system further includes:

control means to enable said ozone generating radiation source for a first predetermined time interval and enable said germicidal radiation source for a second predetermined time interval;

wherein said control means enables said germicidal radiation source subsequent to expiration of said first predetermined time interval.

7. The system of claim 5 wherein said object is a human hand.

8. In combination:

an electrical device performing a function other than purifying air and including air flow means for facilitating an air flow from a surrounding environment through said electrical device; and

an air sterilizer for purifying air flowing within said electrical device, said air sterilizer including:

an air intake to receive an air stream from within said electrical device;

an ozone chamber including an ozone generating radiation source for irradiating the air stream to produce ozone to remove contaminants from within the air stream, and ozone distribution means for reducing air stream through-flow velocity to increase residence time of said air stream in said ozone chamber to enable the produced ozone to thoroughly mix and interact with and ozonate the air stream and thereby enhance removal of contaminants from within the air stream;

a germicidal chamber for receiving said air stream from said ozone chamber and including a germicidal radiation source for irradiating the air stream to remove residual contaminants and ozone therefrom; and

an exhaust to direct the air stream from said germicidal chamber to the electrical device interior for return to the surrounding environment.

9. The combination of claim 8 wherein said electrical device includes a vacuum cleaner.

10. The combination of claim 8 wherein said electrical device includes a computer.

11. In an air sterilization system having an air intake, ozone and germicidal chambers, and an exhaust, a method of producing ozone enriched air to remove contaminants from objects comprising the steps of:

(a) receiving an air stream from a surrounding environment via the air intake;

(b) directing the air stream to flow through the system;

(c) placing an object within a receptacle disposed in the ozone chamber;

(d) irradiating the air stream within the ozone chamber via an ozone generating radiation source to produce ozone to remove contaminants from within the air stream resulting in an ozonated air stream;

(e) configuring the receptacle to enable the ozonated air stream to infiltrate the receptacle and remove contaminants from the object;

(f) irradiating the air stream received from the receptacle in the ozone chamber within the germicidal chamber via a germicidal radiation source to remove residual contaminants and at least a portion of ozone therefrom to produce sterilized air; and

(g) returning the sterilized air to a surrounding environment via the exhaust.

12. The method of claim 11 wherein step (e) further includes:

(e.1) configuring the receptacle to include a porous material to enable the ozonated air stream to infiltrate the receptacle and remove contaminants from the object .

13. The method of claim 12 wherein step (e.1) further includes:

(e.1.1) configuring the receptacle to include mesh netting to enable the ozonated air stream to infiltrate the receptacle and remove contaminants from the object.

14. In an air sterilization system having an air intake and a treatment chamber, a method of producing ozone enriched air to remove contaminants from objects comprising the steps of:

(a) receiving an air stream from a surrounding environment via the air intake;

(b) directing the air stream to flow through the system;

(c) disposing an object within the treatment chamber;

(d) irradiating the air stream within the treatment chamber via an ozone generating radiation source to produce ozone;

(e) increasing residence time of the air stream within a soaking chamber disposed proximate the ozone generating radiation source to enable the produced ozone to thoroughly mix and interact with and ozonate the air stream;

(f) directing the ozonated air stream toward the object to interact with and remove contaminants from the object; and

(g) irradiating the object within the treatment chamber via a germicidal radiation source to remove residual contaminants and ozone therefrom.

15. The method of claim 14 wherein the ozone generating radiation source and the germicidal radiation source are each independent radiation sources, wherein step (d) further includes:

(d.1) enabling the ozone generating radiation source for a first predetermined time interval; and

step (g) further includes:

(g.1) enabling the germicidal radiation source for a second predetermined time interval subsequent to expiration of the first predetermined time interval.

16. The method of 14 wherein the object includes a human hand, and step (c) further includes:

(c.1) inserting a user's hand within the treatment chamber.

17. A method of purifying air within an electrical device, wherein the electrical device performs a function other than purifying air and includes air flow means to facilitate an air flow through the device, said method comprising the step of disposing an air sterilizer within the electrical device in the air flow path for exposing an air stream within the electrical device to ozone and germicidal radiation to remove contaminants residing in the air stream and directing sterilized air to the electrical device interior for return to the surrounding environment.

18. The method of claim 17 wherein said electrical device includes a vacuum cleaner.

19. The method of claim 17 wherein said electrical device includes a computer.

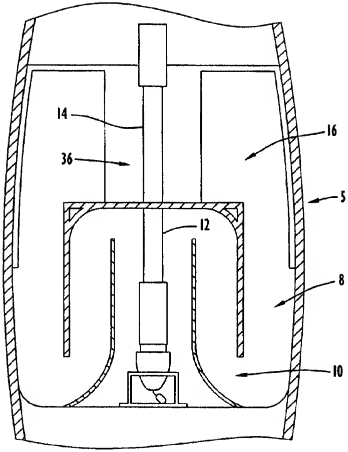

FIG.1

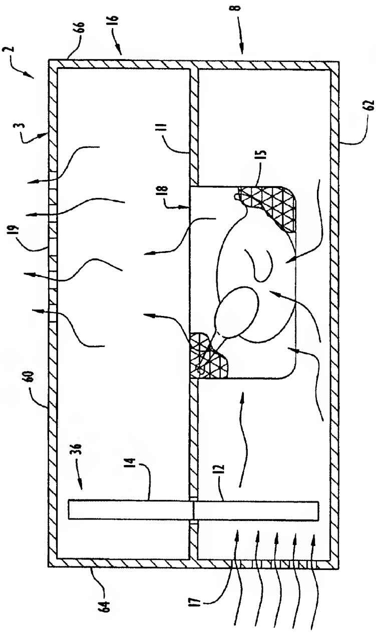

FIG.2

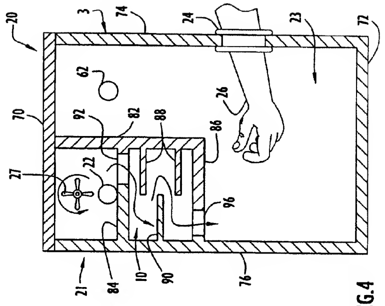
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FIG.4

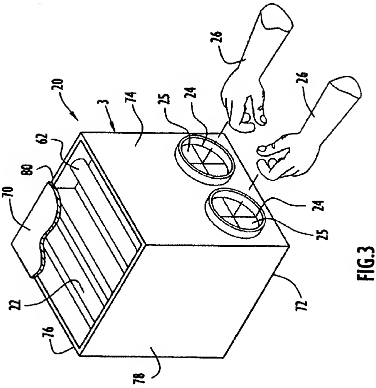
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FIG.3

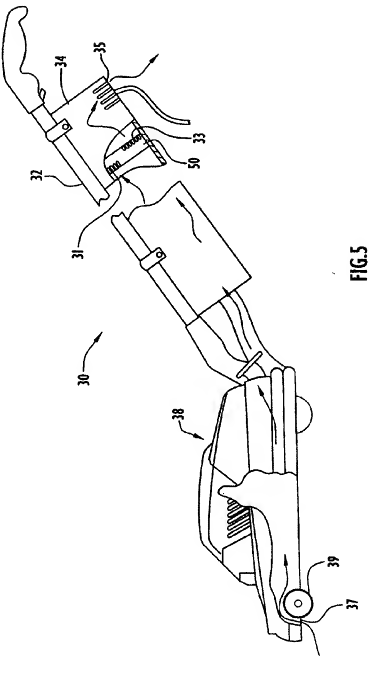

FIG.5

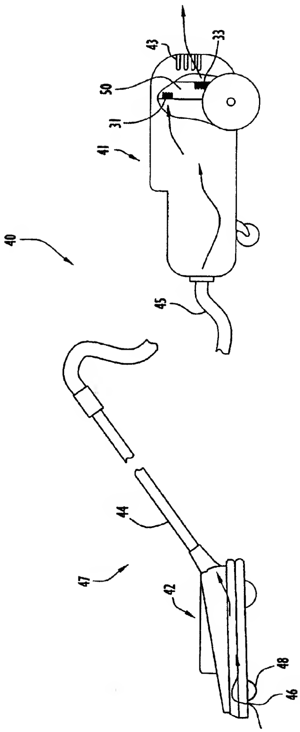

FIG.6